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Larsén, Xiaoli Guo; Larsen, Søren Ejling; Lundtang Petersen, Erik

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The full scale spectrum of the boundary layer wind

Xiaoli Larsen, Søren E. Larsen, and Erik Lundtang Petersen

DTU Wind Energy, Technical University of Denmark, Roskilde, Denmark (erlu@dtu.dk)

For many years the safe construction of buildings has required norms and standards based on reliable statistics of local wind conditions. Over the years a more and more accurate statistical description of the wind has been requested to set new standards for the exact determination of the wind conditions on specific locations, especially with regard to the power production over the lifetime of wind turbines, to the optimal design of wind turbines and to the predictability of wind farm output hours and days ahead.

It has been, for almost a century, common practice to describe the movement of the air in the atmospheric boundary layer on three distinct space and time scales: the synoptic scale, the mesoscale and the microscale, the distinction being 1000km 2D; 100km or less 2D and 3D; 1 km and less 3D. (D=dimensional)

Here we investigate if a distinct “GAP” exists between the 2D motions in the mesoscale and the microscale’s 3D turbulence in the lowest 100 m. The importance of this Gap is so evident, that despite the first documentation of the Gap was seriously questioned by later studies, its existence is implicitly assumed in all kinds of parametrization in today’s mesoscale modelling, LES and CFD modelling.

We found that a “GAP” exists between the mesoscale and the microscale, range 10min to 1 hour, and heights from 10 m to 100 m, under the assumption that the mesoscale processes and the microscale processes are only weakly correlated.

Our analysis is based on some extraordinary datasets from two wind energy sites in Denmark: A coastal test station (Høvsøre) located 2 km from the North Sea coast and an offshore site 20 km off the coast in the North Sea. The dataset comprises several long term dataset of 20 Hz and 12 Hz sonic data over land and sea and cup anemometer dataset over several years and heights from 10 to 100 meters.